Persistence is a Virtue: Energy Efficiency Measurement and Verification (M&V)

M&V Models, Tools, and Automation

October 23, 2014

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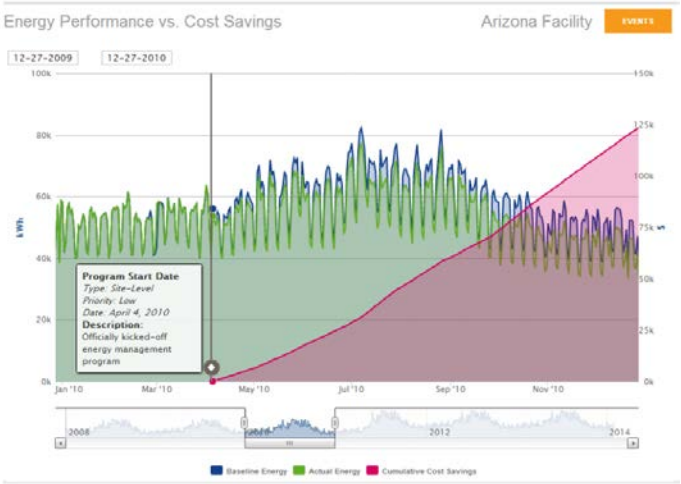
Outline

- What is Automated Measurement and Verification (M&V)?
- Overview of Automated M&V Tool Types
- Accuracy, Uncertainty, and User Requirements
- How Is Energy Performance Verification Used in New Construction?

What is Automated M&V?

- The use of emerging software tools, intelligent analytics, and metered building energy data
  - To streamline and simplify the process of quantifying energy savings



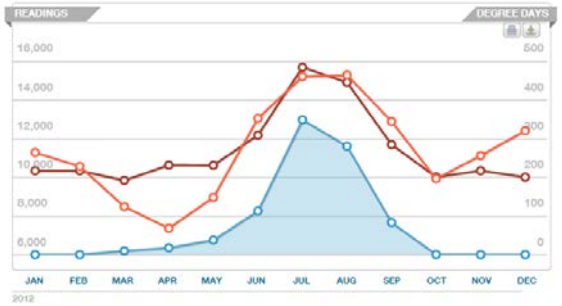
SENSEI™ ENERGY EFFICIENCY PLATFORM

How is Automated M&V Different Than Classical M&V?

Classical M&V

- Engineer with deep expertise in buildings
- Tailored models constructed building-by-building
- M&V plan tailored to project
- “Non-routine” adjustments
- Spreadsheets, engineering calculations, (‘non-routine’) data adjustments, spot measures
- Higher accuracy, cost, and labor intensity

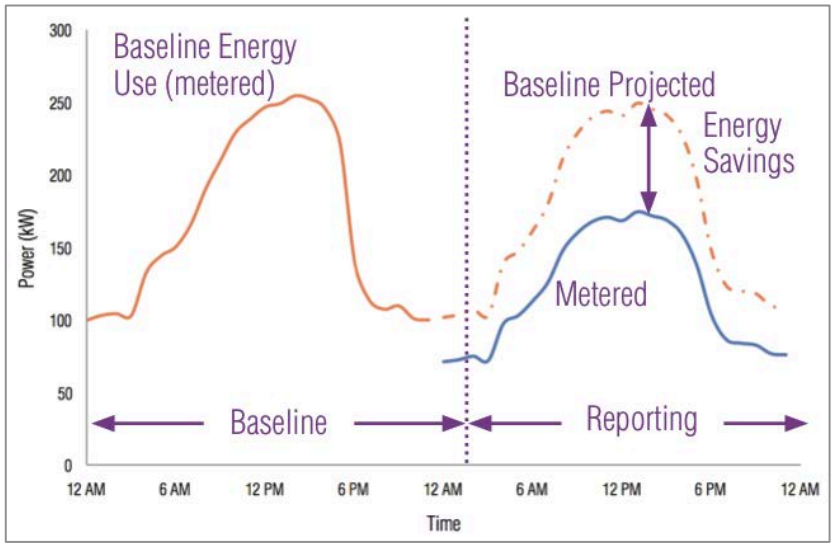
Automated M&V



- No expert required
- General model, ‘fit’ to specific building
- No custom M&V plan
- No “non-routine” adjustments
- Packaged software, utility data or submetered data
- Potentially trade accuracy for reduction in cost and labor

How is Automation Achieved?

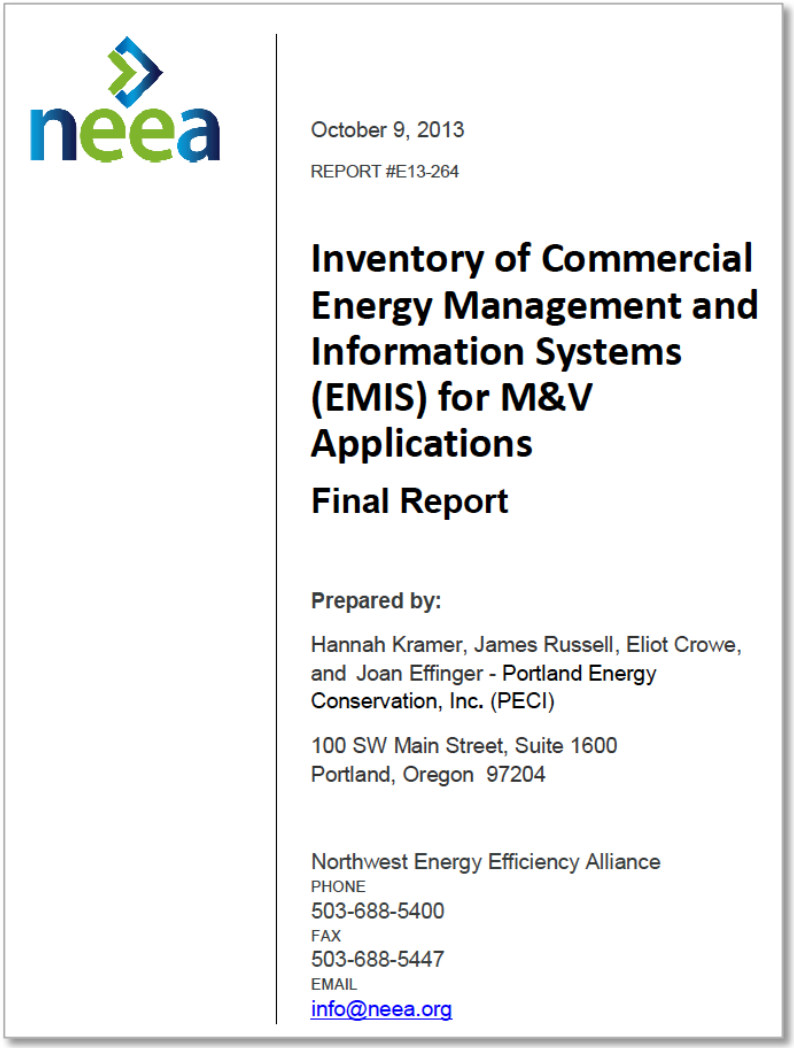
- Baselines are automatically created using
  - Historic energy use data, system level or whole-building
  - weather data feeds
- Baseline = equation that expresses energy use in terms of key 'drivers'
  - e.g., weather, time of day/week
- Regression, neural networks, bin models most common baseline types
- User enters date that improvements began
- Tool projects baseline and calculates savings as difference from metered use



What Metering and Other Data is Typically Used?

- Energy use data can be monthly, hourly, or sub-hourly, depending on the tool
- Energy use may be measured at the whole-building, system, or submeter level
- Building-specific operational schedules, or other characteristics may be used to better fit the model to the building
- There are also tools that deliver calibrated simulation modeling for M&V

NEEA/PECI Resource: Inventory of Analytical Tools That Offer M&V



October 9, 2013

REPORT #E13-264

Inventory of Commercial Energy Management and Information Systems (EMIS) for M&V Applications

Final Report

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*Companion report for industrial tools recently released

4. Findings

The final inventory is populated with fourteen EMIS, which are shown below.

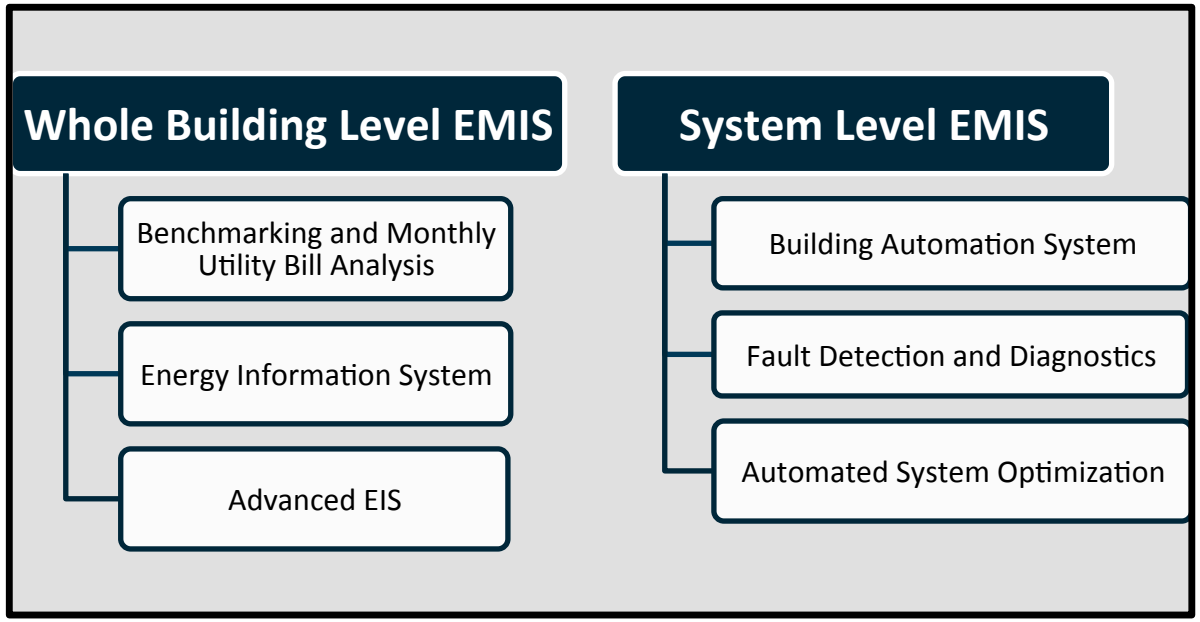
Table 4. EMIS Included in the Inventory

Vendor	EMIS	Data Input Frequency	M&V	Opportunity Identification	Project Tracking
Cascade Energy	Sensei	< Hourly	Option C[i]		Advanced
Elster EnergyICT	EIServer Platform	< Hourly	Option C		Advanced
Energent	Energent	< Hourly	Option C		Advanced
EnergyCAP	EnergyCAP Enterprise	Monthly	Option C		Basic
EnergyRM	DeltaMeter	Monthly	Option D[ii]		
EnerNOC	Efficiency Smart Insight	< Hourly	Option C	Yes	Basic
eSight Energy	eSight Energy	< Hourly	Option C		Basic
FirstFuel	Rapid Building Assessment	< Hourly	Option C	Yes	Basic
Johnson Controls	Energy Performance Monitor	< Hourly	Option C		Basic
MACH Energy	MACH Asset Manager	< Hourly	Option C		Basic
Noesis	Noesis	Monthly	Option C		Advanced
NorthWrite	Energy Worksite	< Hourly	Option C		Advanced
Pulse	Energy Manager	< Hourly	Option C		Basic
Retroficiency	Virtual Energy Assessment (VEA) Automated Energy Audit (AEA)	< Hourly	Option D	Yes	

Notes: i. International Performance Measurement and Verification Protocol (IPMVP), Option C: Actual vs. normalized/adjusted baseline. ii. IPMVP Option D: Calibrated simulation

Automated M&V Tool Types

- Majority of tools that offer automated M&V belong to a family called energy management and information systems (EMIS)

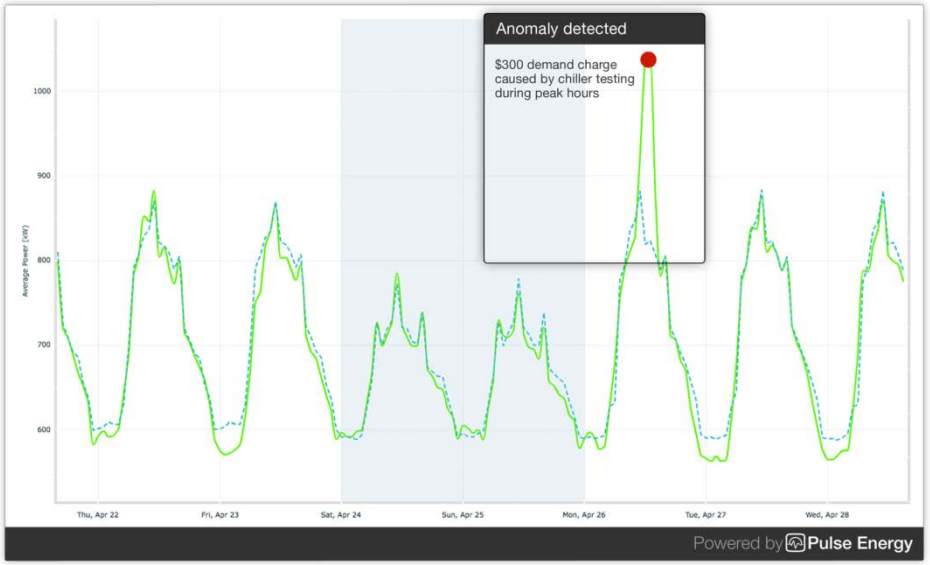


*The lines can be blurry, and specific technologies may cross categories

Automated M&V Tool Types

- Each type of EMIS offers diverse features and capabilities

- PECI identifies those that are most common among the subset of EMIS that offer M&V
  - Web-based, hosted cloud services
  - Customizable interfaces, user-defined graphs and tables
  - Manual tabular data import by user or vendor, and/or continuous data acquisition
  - Downloadable predicted energy use in tabular format



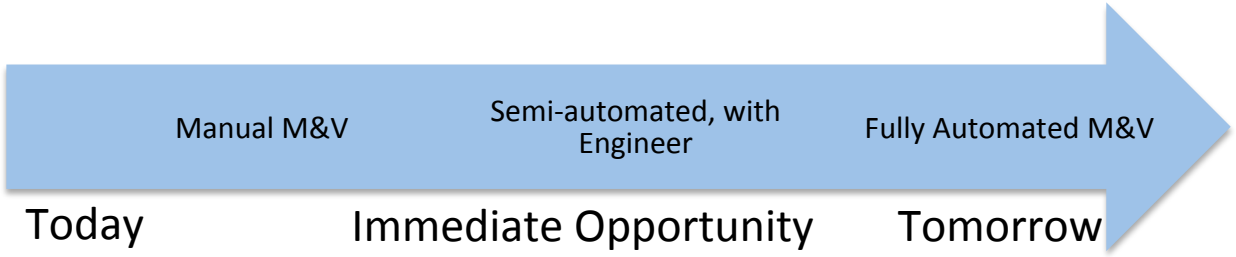
Advanced EIS: a time series graph identifying excessive energy use with a predictive baseline energy model

Promise for the Industry

- Today, energy savings are most often 'deemed' *not* measured and verified
  - Savings that *should* be achieved may not be *actually* be realized
  - Savings beyond what is expected may not be accounted for, credited
  - Without verification, there can be skepticism that savings are real

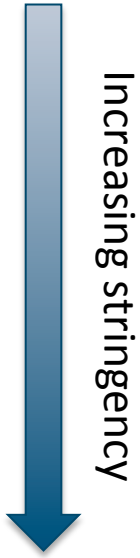
- However, M&V can be complex and costly, requires engineering expertise, and is difficult to scale

- Emerging tools and growing availability of data offer the promise to
  - Routinely track and quantify energy savings with lower costs
  - Lending credibility and transparency to efficiency efforts
  - Facilitating increased investment and improved operations



Accuracy, Uncertainty, Diverse Requirements

- There are potential tradeoffs between accuracy, time, and cost for M&V, especially when considering the use of automated tools
- Predictability of building loads, data granularity, depth of savings, all impact accuracy
- There are many "users" of M&V, with diverse requirements for accuracy
  - Building owner with self-directed projects
  - Campus or corporate energy manager with financial accountability
  - M&V agent/practitioner
  - ESCO engaged in guaranteed or shared savings contracts
  - Utility delivering efficiency programs



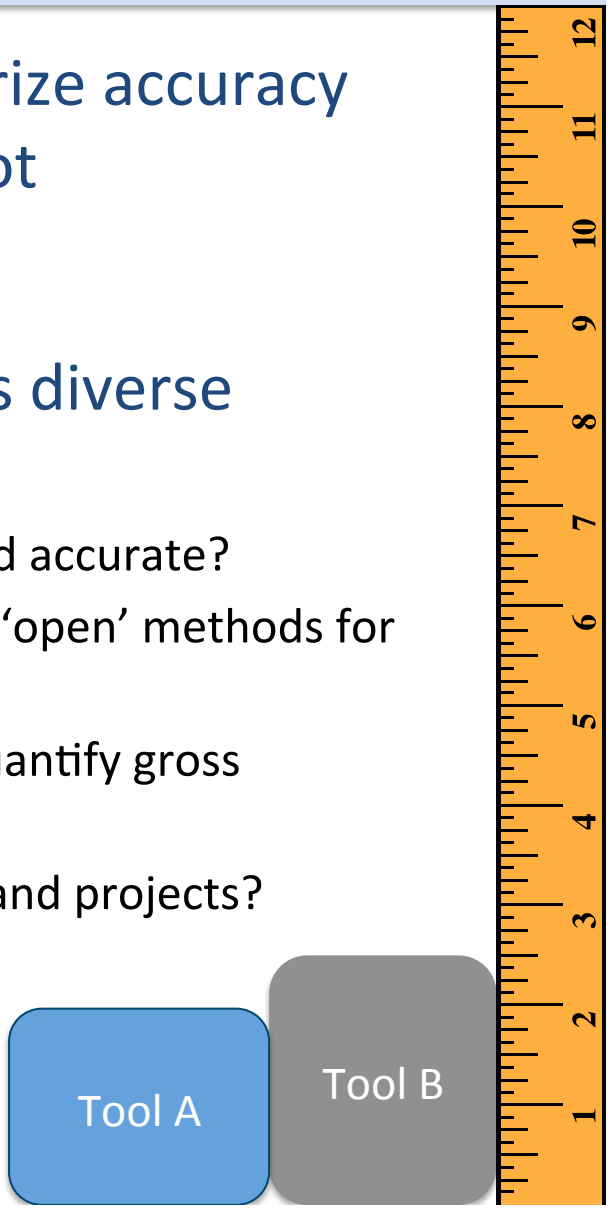
Using Tools that Automate M&V

- Considerations:
  - Buildings/systems with more predictable, regular operations and loads will be easier to handle
  - The deeper the savings (%), the easier they are to "see" in the building
  - Are you willing to potentially trade some accuracy, for lower costs and decreased complexity in the M&V process?
  - **Can you make good use of the other features that the tool offers, to make the most of your investment?**
- Costs
  - Free, *semi-automated*: Universal Translator 3, ASHRAE Inverse Modeling Toolkit, ECAM
  - Costs of tools that offer fully *automated* M&V vary dramatically
    - Recent LBNL study found median 5-yr costs ~$1,800/monitoring-point, for large enterprise/portfolio implementations of EIS and Advanced EIS

What Is Industry Asking?

- Some tools provide statistics that characterize accuracy of baseline model predictions, others do not

- Common questions being asked among this diverse audience of M&V "users" are:
  - How can I determine whether a given tool is robust and accurate?
  - How can I compare and contrast proprietary tools and 'open' methods for M&V?
  - How can we reduce the time and costs necessary to quantify gross savings?
  - Can I use a whole-building approach for my programs and projects?



Research, Collaborations to Address Accuracy and Uncertainty

PG&E-ET funded Whole-Building Savings Estimation

- Developed procedure to test accuracy tools, baseline models for whole-building M&V
- Used to prequalify tools for inclusion in 2013-2014 Whole Building pilot, 15% multi-measure savings target

PGE Team: Leo Carillo, Mananya Chansanchai, Mangesh Basarkar, Ken Gillespie

CEE whole buildings committee: key metrics and acceptance criteria for models/tools to streamlined delivery of whole-building programs

DOE Building Technologies Office: Build national awareness and buy-in, solicit advanced models, test with nationally diverse data set, publish results for increased transparency, uptake and adoption

Find out more at eis.lbl.gov

How Is Energy Performance Verification Used in New Construction?

Energy Performance Verification and New Construction

- In new construction, best-practice efforts may establish an energy performance target
  - Target is verified post-occupancy
  - And continuously managed to during operations

- UC Merced offers an example of this practice

UC Merced

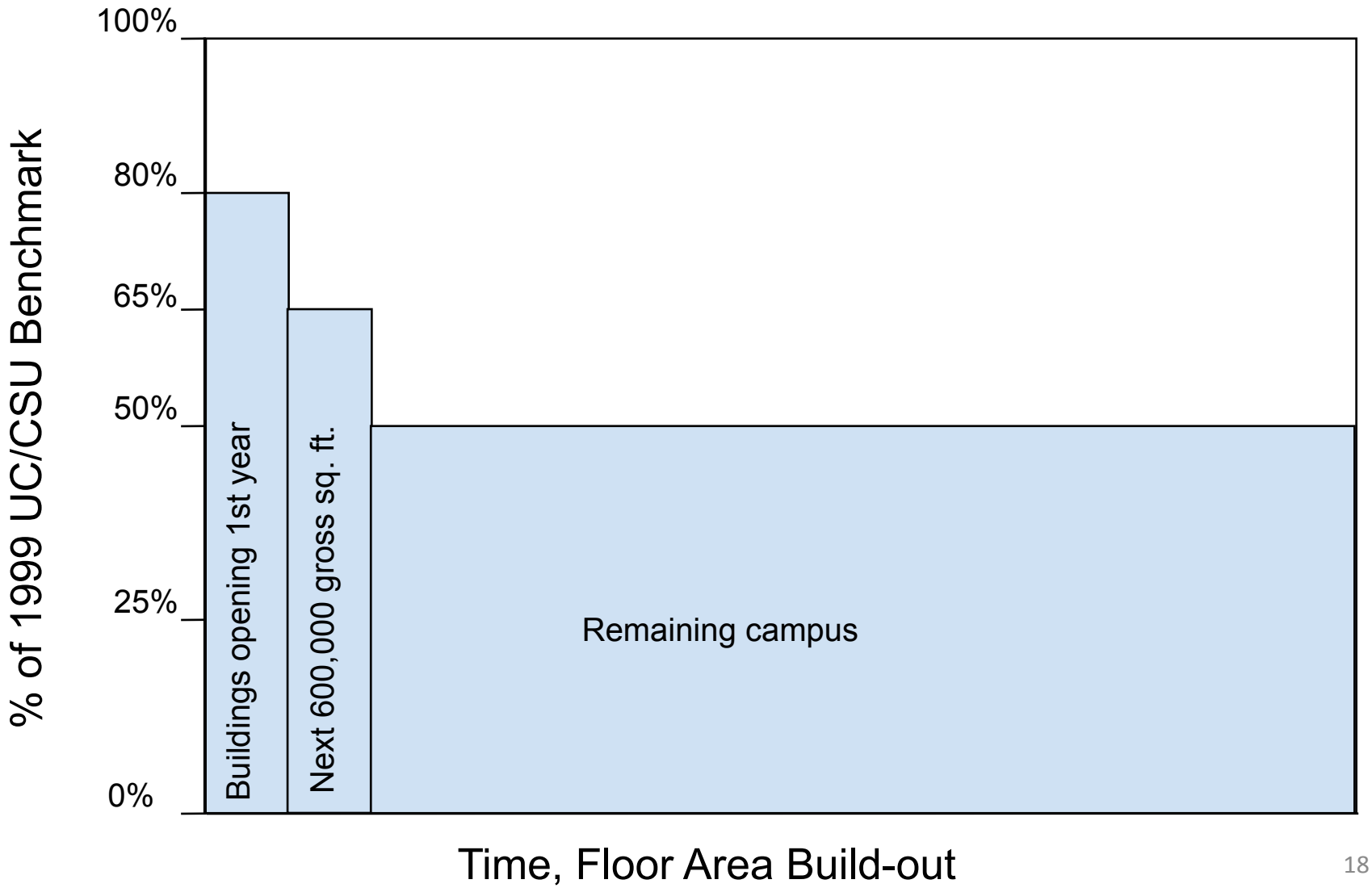
- Newest university in the UC system
- Long range development plan, 25,000 students
- Energy performance targets set relative to UC/CSU common benchmark case (Karl Brown, 2002)
  - All cooling loads served by electricity, no thermal energy storage or co-generation
- General form of benchmark

  Energy/Demand (per sq. ft.) = a + b (% lab buildings) + c (climate variable)
- Example, Maximum Electric Demand

  Watts/gsf = 0.85 + 4.0 (% Lab Buildings) + 0.067 (CD65)

  CD65 = Cooling Design Temp - 65 degF

UC Merced Energy Performance Targets



Managing To the Energy Target

- Extensive monitoring – 10K points for central plant and first 3 buildings
- Campus, building, and end-use tracking using EMIS, with ALC Web-Control as data foundation

A- How is my energy performance?
Benchmark Performance

B- Is consumption rising or falling? What end use is driving changes in consumption?
Energy Consumption

C-Are peak demands rising or falling? What end use is driving changes in peak demand?
Energy Demand

D-Are central plant efficiencies improving or declining?
Plant Efficiencies

E-Are system efficiencies improving or declining?
System Efficiencies

F-Are systems operating properly? Hoe much energy is being wasted?
Setpoint Analysis

G- How can future building energy models be improved?
Modeling Inputs

BERKELEY LAB

UNIVERSITY OF CALIFORNIA
UCMERCED

Energy Performance Platform

UC Merced is currently designing buildings to consume half the energy and peak demand of other university buildings in California.

This goal has been phased in over time, with building energy budgets initially set at 80% and then 65% of 1999 UC/CSU building benchmarks. The campus is currently operating at 70% of benchmark with two buildings operating below 65% of benchmarks (source energy).

Surpassing efficiency goals has led the campus to strive for a zero net energy goal by 2020. To asses UC Merced's building performance, LBNL and UC Merced developed the EPP to ensure monitoring performance and identifying savings.

Energy Consumption

Area: COB
Commodity: Electricity
Unit: kWh
Boundary: Source

Show End Uses?
Yes ● No ○

- [X] HVAC CHW
- [X] HVAC Fan
- [X] HVAC Pump
- [X] Plug load
- [X] Lighting

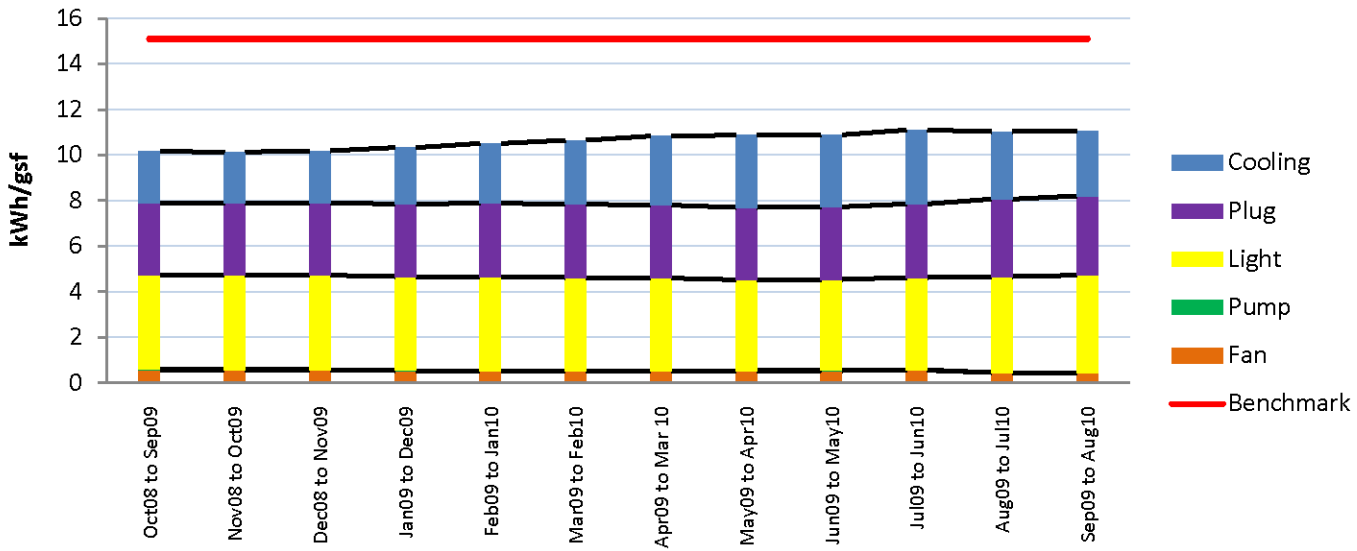
Divisor: MGSF
Filter: None
Comparator: Benchmark

Range: Yearly
From: 09/09
Through: 08/10

Reset Submit

Home

COB-Electric Energy Consumption Intensity



Equation SQL Statement Data Table Plot Metric Data Download Metric Data

The total electric demand is a rolling 12-month average, calculated by dividing the logged electric use at COB's main breaker by the gross square footage. The total is then broken up into end uses.

Setpoint Analysis

System: Zone Temp & Flow
Aspect: Operational
Component: AH-9: 3rd NW

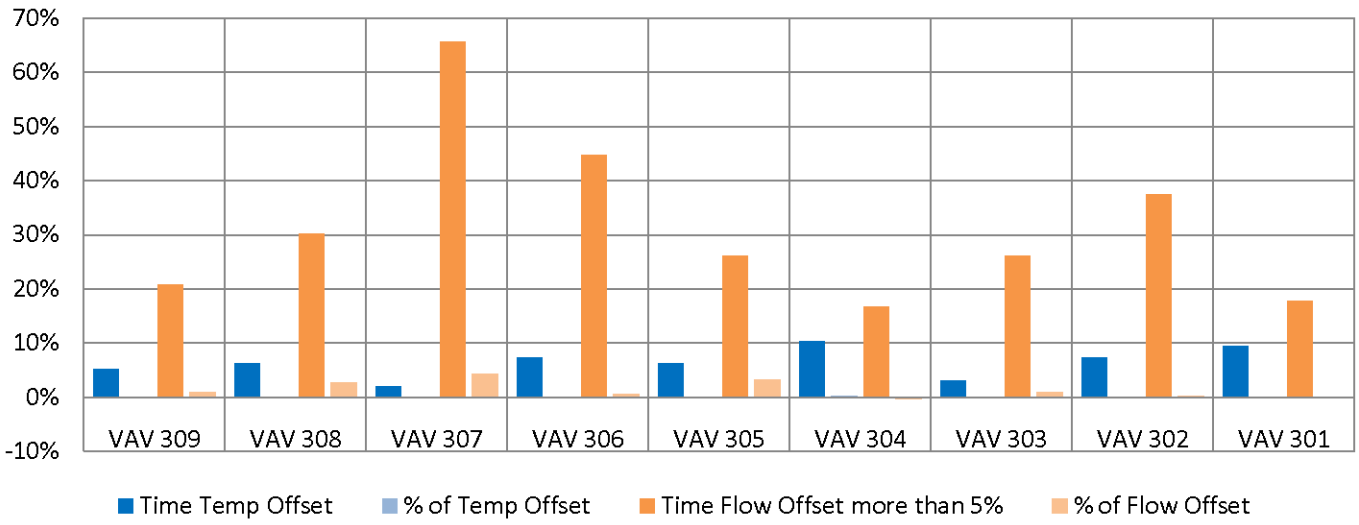
Divisor: None
Filter: None

Range: Monthly
From: 07/10
Through: 07/10

Reset Submit

Home

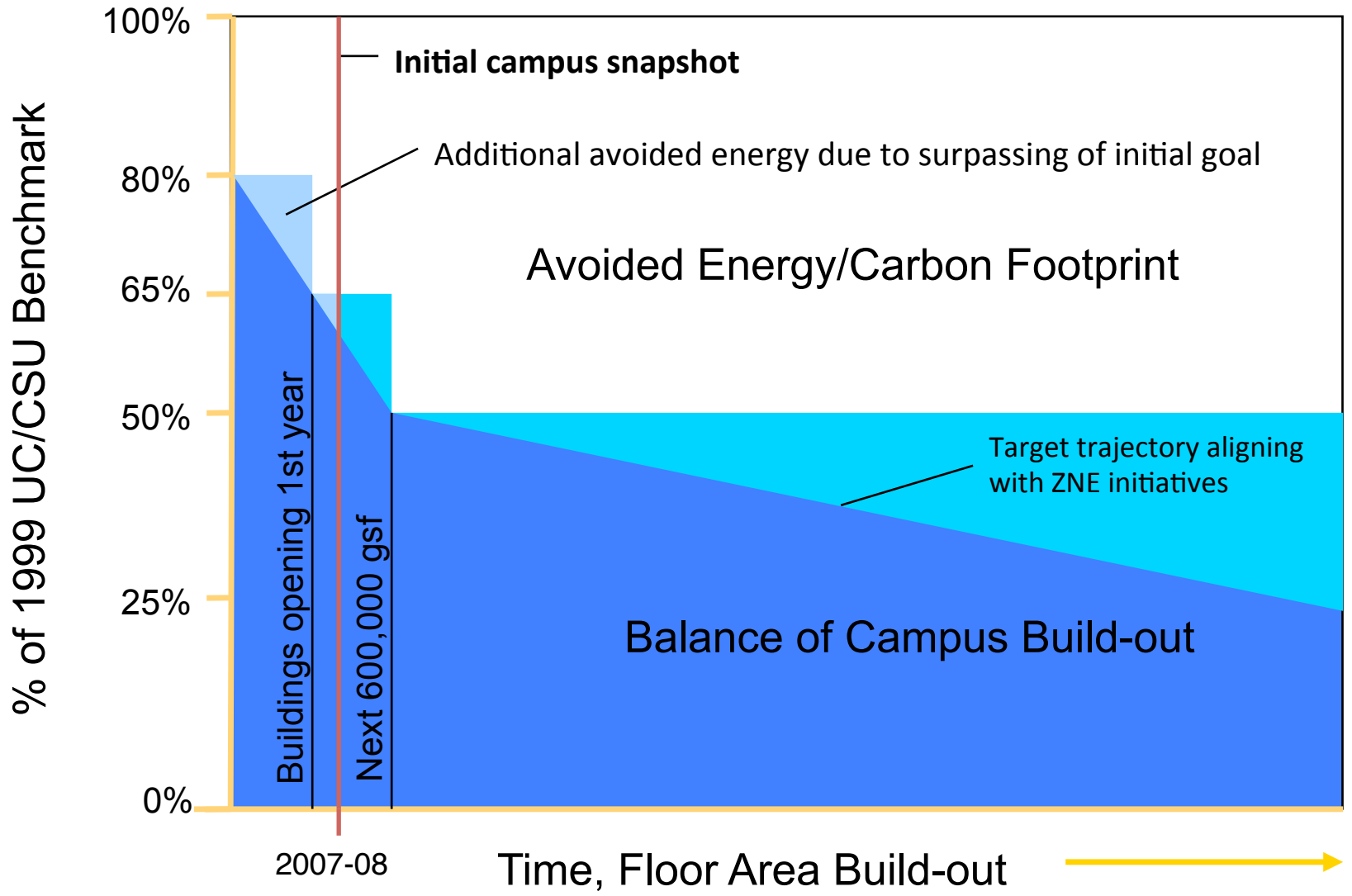
3rd Floor- NW Wing



Equation SQL Statement Data Table Plot Metric Data Download Metric Data

Characterizes the overall efficiency of the cooling system (including chillers, pumps, cooling towers) in terms of the energy input per unit of cooling output.

Meeting the Target



UC Merced Key Takeaways

- Start with energy efficiency
- Set bold but achievable goals and build on them
- Collect data to verify and track performance, and cultivate a living laboratory
- Create organizational structures and a process to further efficiency, sustainability

Thank You!

Questions?

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